Patents Form 1/77

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Request for the grant of a patent

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The Patent Office

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1. Your reference

REP05969GB

2. Patent application number
(The Patent Office will fill in this part)

22 DEC 1998 **9828346.8**

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Microscience Ltd.
67-68 Jermyn Street
London
SW1Y 6NY
United Kingdom

Patents ADP number *(if you know it)*

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

07304544001.

4. Title of the invention

PROTEIN AND COMPOSITIONS CONTAINING IT

5. Name of your agent *(if you have one)*

GILL JENNINGS & EVERY

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Broadgate House
7 Eldon Street
London
EC2M 7LH

Patents ADP number *(if you know it)*

745002

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

YES

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	6 /
Claim(s)	1 /
Abstract	
Drawing(s)	2 + 2 - 100

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. For the Applicant
Gill Jennings & Every

I/We request the grant of a patent on the basis of this application.

Signature: Lucy Fennels

Date: 22 December 1998

12. Name and daytime telephone number of person to contact in the United Kingdom

PERRY, Robert Edward
0171 377 1377

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Notes

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PROTEIN AND COMPOSITIONS CONTAINING IT

Field of the Invention

This invention relates to one protein, to vaccines containing it, and to its use in therapy, for immunisation.

Background to the Invention

Group B Streptococcus (GBS), also known as *Streptococcus agalactiae*, is the causative agent of various conditions. In particular, GBS causes:

Early onset neonatal infection.

This infection usually begins *in utero* and causes severe septicaemia and pneumonia in infants, which is lethal if untreated and even with treatment is associated with a 10-20% mortality rate.

Late onset neonatal infection.

This infection occurs in the period shortly after birth until about 3 months of age. It causes a septicaemia, which is complicated by meningitis in 90% of cases. Other focal infections also occur including osteomyelitis, septic arthritis, abscesses and endopthalmitis.

Adult infections.

These appear to be increasingly common and occur most commonly in women who have just delivered a baby, the elderly and the immunocompromised. They are characterised by septicaemia and focal infections including osteomyelitis, septic arthritis, abscesses and endopthalmitis.

Urinary tract infections.

GBS is a cause of urinary tract infections and in pregnancy accounts for about 10% of all infections.

Veterinary infections.

GBS causes chronic mastitis in cows. This, in turn, leads to reduced milk production and is therefore of considerable economic importance.

GBS infections can be treated with antibiotics. However, immunisation is preferable. It is therefore

desirable to develop an immunogen that could be used in a therapeutically-effective vaccine.

Summary of the Invention

According to the present invention, a partial GBS gene sequence for the protein Ornithine Carbamoyltransferase (OCT) has been found which represents an outer surface protein.

In one aspect of the invention, the use of this protein in a recombinant protein vaccine is described. This vaccine may be administered to females either prior to, or during pregnancy to protect mother and neonate against infection by GBS.

The gene sequence may be first genetically altered to increase the antigenicity of the encoded protein.

Brief Description of the Drawings

The invention will now be described in detail with reference to the accompanying figures, wherein:

Figure 1 shows the partial nucleotide sequence and the deduced amino acid sequence of the GBS OCT.

Description of the Invention

Because of its extracellular or cell surface location, the protein of the present invention may be a suitable candidate for the production of therapeutically-effective vaccines against GBS. The term "therapeutically-effective" is intended to include the prophylactic effect of the vaccines. For example, a recombinant protein may be used, as an antigen for direct administration to a patient. The protein may be isolated directly from GBS or expressed in any suitable expression system, e.g. *Lactococcus lactis*. It is preferably administered with an adjuvant, e.g. alum.

The protein may be a mutant protein in comparison to wild-type protein, a fragment of the protein or a combination of different fragments, provided an effective immune response is generated.

An alternative approach is to use a live attenuated GBS vaccine. This may be produced by deleting the gene that encodes the protein. Preferably, the GBS strain

comprises additional virulence gene mutations.

The protein (or fragments thereof) of the present invention may also be used to produce monoclonal and polyclonal antibodies for use in passive immunisation.

In a further embodiment of the invention, the protein or corresponding polynucleotide may be used as a target for screening potentially useful drugs, especially antimicrobials. Suitable drugs may be selected for their ability to bind to the protein to exert their effects. Assays for screening for suitable drugs and which make use of the protein of the invention will be apparent to those skilled in the art.

Although the protein has been described for use in the treatment of patients, veterinary uses of the protein are also considered to be within the scope of the present invention. In particular, the protein or the vaccines may be used in the treatment of chronic mastitis, especially in cows.

The present invention is described with reference to Group B Streptococcal strain M732. However, all the GBS strains and many other bacterial strains are likely to include related proteins having amino acid sequence homology with the protein of M732. Organisms likely to contain the proteins include, but are not limited to, *S. pneumoniae*, *S. pyogenes*, *S. suis*, *S. milleri*, Group C and Group G *Streptococci* and *Enterococci*. Vaccines to each of these may be developed in the same way as described for GBS.

Preferably, the proteins that may be useful for the production of vaccines have greater than 40% sequence similarity with the protein of M732. More preferably, the proteins have greater than 60% sequence similarity. Most preferably, the proteins have greater than 80% sequence similarity.

The protein of the present invention was identified as follows:

Todd-Hewitt Broth was inoculated with GBS and allowed

to grow overnight at 37°C. The cells were harvested by centrifugation and washed with Phosphate Buffered Saline (PBS). The cells were resuspended in an osmotic buffer (20%(w/v) Sucrose, 20mM Tris-HCl pH 7.0, 10mM $MgCl_2$) containing protease inhibitors (1 mM PMSF, 10 μM Iodoeacetic Acid, 10 mM 1,10-Phenanthroline, 1 μM Pepstatin A) and Mutanolysin at a final concentration of 4 Units per microlitre. This was incubated (shaking) at 37°C for 2 hours.

Cells and debris were removed first by high speed centrifugation, then ultra-centrifugation for 1 hour. The resultant supernatant containing cell wall proteins was concentrated under pressure using an ultrafiltration device (10,000 molecular weight cut-off).

The sample was dialysed against ultra high quality water and lyophilised. After resuspension in loading buffer, the proteins were separated by preparative 2-Dimensional-Gel Electrophoresis. Following Electrophoresis an individual spot was chosen for study. The spot was subjected to in-gel tryptic digestion. The resulting peptides were extracted from the gel and purified using microbore RP-HPLC. Fractions were collected every 45 seconds and a portion of these consistent with the regions of UV absorbance were analysed by Delayed Extraction-Matrix Assisted Laser Desorbtion-Time of Flight Mass Spectrometry (DE-MALDI-TOF-MS). Peptides not observed in a blank preparation were then subjected to sequencing using Nanospray-MS/MS

The Peptide Sequences obtained are shown in Figure 2a.

Using this information, degenerate oligonucleotides were designed to be used in a polymerase chain reaction (PCR) to amplify the DNA segment lying between the peptide sequences identified. The sequences of these oligonucleotides is shown in Figure 2b.

PCR amplification resulted in the production of an (approximately) 250 base pair fragment, which was cloned into the pCR 2.1-TOPO vector (Invitrogen BV, Netherlands)

according to manufacturers protocol. This plasmid was termed MS4. The cloned DNA fragment was sequenced (Figure 1) and the deduced amino acid sequence was used to search protein databases. Results of this search are shown in Table 1.

As shown in Table 1, homologues to the GBS MS4 gene product can be identified in *Clostridium perfingens*, *Haemophilus influenzae*, *Neisseria flavescens* and *Thermatoga maritima*. In all cases the homologues are the genes for Ornithine Carbamoyltransferase (OCT). In eukaryotic systems this enzyme catalyses the second step in the Urea cycle, the conversion of ornithine to citrulline, a reaction requiring carbomyl phosphate. In prokaryotes, ODC is one of the three enzymes involved in Arginine Deaminase activity - a system which protects bacteria from acid damage. In particular, ODC is responsible for the conversion of citrulline to ornithine and carbamoyl phosphate (the opposite role to that in eukaryotes) (Casiano-Colon, A and Marquis, R. E. 1988. Appl. Environ. Microbiol. 54: 1318-1324, Cunin, R. et al. 1986. Microbiol. Rev. 50: 314-352).

Table 1. Database search results for MS4

Organism	Protein Accession	DNA Accession	Gene Name	% Similarity	% Identity	Alignment Length
Clostridium perfringens	Q46169	X97768	Ornithine Carbamoyltransferase	80	58	246
Haemophilus influenzae	P44770	1573585	Ornithine Carbamoyltransferase	77	57	246
Neisseria. flavescens	Q01323	X64872	Ornithine Carbamoyltransferase	79	55	246
Thermatoga maritima	P96108	Y10661	Ornithine Carbamoyltransferase	63	48	246

CLAIMS

1. A protein comprising an amino acid sequence encoded by the polynucleotide defined as MS4 in Figure 1 or a homologue thereof with at least 60% sequence homology.

2. A protein according to claim 1, obtainable from the Group B streptococcal strain M732.

3. A protein according to claim 1 or claim 2, wherein MS4 comprises the nucleotides 1-252.

4. A protein according to any of claims 1 to 3, for use in a method of therapy.

5. A polynucleotide which encodes a protein according to any preceding claim, its complement, or a fragment thereof.

6. The use of a bacterial protein according to any of claims 1 to 4, in the manufacture of a vaccine to treat bacterial infection.

7. The use according to claim 6, wherein the infection is a Group B streptococcal infection.

8. The use according to claim 6 or claim 7, wherein the infection is a focal infection.

9. The use according to claim 6 or claim 7, wherein the infection is a urinary tract infection.

10. Use of a product according to any of claims 1 to 5, for screening potential antimicrobial drugs.

11. An antimicrobial drug selected using the products as defined in claim 10.

12. A vaccine comprising a product according to any of claims 1 to 5.

13. A vaccine comprising a microorganism having a virulence gene deletion, wherein the gene codes for a protein according to any of claims 1 to 4.

14. An antibody raised against a protein according to any of claims 1 to 4.

Figure 1. Nucleotide and deduced amino acid sequence of clone MS4

```
        10                  30                  50
TTTCCAGCTGAAGAGATTGTTAAATTGGCTGAAGGATATGCCAAAGAATC
F  P  A  E  E  I  V  K  L  A  E  G  Y  A  K  E  S

                    70                  90
TGGGGCTCACGTTCTCGTTACTGATAATGTAGACGAAGCTGTAAAGGGAG
 G  A  H  V  L  V  T  D  N  V  D  E  A  V  K  G  A

       110                 130                 150
CAGACGTCTTTTACACTGATGTCTGGGTATCGATGGGAGAAGAAGATAAG
  D  V  F  Y  T  D  V  W  V  S  M  G  E  E  D  K

                   170                 190
TTCAAAGAACGCGTTGAACTTCTTCAACCATATCAAGTAAACATGGAACT
F  K  E  R  V  E  L  L  Q  P  Y  Q  V  N  M  E  L

 210                 230                 250
GATTAAAAAAGCTAATAATGATAATCTTATCTTCTTACGCTGCTTACC
 I  K  K  A  N  N  D  N  L  I  F  L  R  C  L
```

Figure 2a. Generated Peptide Sequences for MS4

PAFHD

FPAEE(L/I)VK

Figure 2b. Oligonucleotide sequences designed from Peptide sequences in Figure 2a

TTTCCAGCTGAAGA

RTCRTGRAADGCHGG

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